

Ultrasonic Arteriography: Implications in Patient Management

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Forty-six consecutive studies of carotid bifurcations were done with a Hokanson Ultrasonic Arteriograph before contrast arteriography. Based on the Doppler signal and the oscilloscopic image, each internal carotid artery was sorted into one of four categories as an estimation of the percent diameter reduction: less than or equal to 10 percent, 10 percent to 49 percent, 50 percent to 99 percent, and total occlusion. These results were compared with the percent diameter reduction determined from contrast arteriograms by a vascular radiologist unaware of the noninvasive test results. Overall, 83 percent of the arteries were correctly categorized. Detection of stenosis in the 50 percent to 99 percent range was 89 percent accurate. The sensitivity and specificity in detecting a 50 percent or greater stenosis were both 96 percent.

STROKE REMAINS the third largest cause of death in the United States.¹ As many as 40 percent of these deaths are the result of arterial occlusive disease occurring at the carotid bifurcation.² In an effort to detect occlusive disease at this location, various noninvasive tests have been devised. Many have serious shortcomings, not the least of which are a lack of patient acceptance and accuracy rates that vary widely from investigator to investigator. One method, ultrasonic arteriography, has been shown by several investigators to

have excellent accuracy and reproducibility as well as patient acceptance.³⁻⁵ We present our results using the ultrasonic arteriograph as developed by Hokanson and discuss the implications such testing may have on patient management.

Patients and Methods

From March 1979 through March 1980, 222 carotid arteries were evaluated with the Hokanson Ultrasonic Arteriograph Model P1 at the Seattle Veterans Administration Medical Center. This instrument uses a 5 MHz pulsed Doppler signal to detect blood flow. When flow is detected, a spot is illuminated on a storage oscilloscope that corresponds to the transducer coordinates. Sequential movement of the transducer in transverse and longitudinal planes results in illumination

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of additional spots, creating a flow map of the underlying artery. The flow map and the audible interpretation of the amplified Doppler shifted signal are used to sort the internal carotid artery into one of four categories depending on the estimated percent diameter reduction.

Category I consists of internal carotid arteries suspected of having less than 10 percent diameter reduction. In these, the Doppler signal is considered normal. Category II comprises internal carotid arteries with suspected diameter reductions of between 10 percent and 49 percent. In these, the Doppler signal is harsh and has a bubbly characteristic but is not associated with an increase in the baseline frequency. Category III comprises internal carotid arteries with a suspected diameter reduction of between 50 percent and 99 percent. In these, the Doppler shifted frequency is substantially increased from the baseline. Category IV comprises those internal carotid arteries with suspected total occlusion. No Doppler signal is obtained from such vessels. Arteries with a 50 percent or greater diameter reduction are considered to have a hemodynamically significant stenosis while those with less than 50 percent diameter reduction are not.

Of the 222 arteries studied, 46 subsequently were studied by arteriography and these form the basis of this report. In each instance, four different projections of the carotid bifurcation, in addition to views of the aortic arch and intracranial circulation, were obtained. The percent diameter reduction of the internal carotid artery was determined in the standard manner by a vascular radiologist unaware of the noninvasive study results. The accuracy of the category placement using the ultrasonic arteriograph was assessed by comparing the ultrasonic arteriograph category against the arteriographically determined percent diameter reduction. Sensitivity and specificity of the ultrasonic arteriograph at a 50 percent diameter reduction threshold were also determined.

Results

Overall, 38 of the 46 carotid arteries (83 percent) were correctly categorized by the noninvasive test as follows: 5 of 6 arteries (83 percent) with less than 10 percent diameter reduction, 13 of 17 arteries (71 percent) with a 10 percent to 49 percent diameter reduction, 16 of 18 arteries (88 percent) with a 50 percent to 99 percent diameter reduction and 4 of 5 totally occluded

arteries (80 percent). Of the 23 arteries with a lesion producing a 50 percent or greater arteriographic diameter reduction, 22 had been so designated by the ultrasonic arteriograph (sensitivity 96 percent). Likewise, 22 of the 23 arteries that had either no stenosis or one of less than 50 percent reduction as shown by arteriography were correctly identified as such using the ultrasonic arteriograph (specificity 96 percent).

Discussion

The ultrasonic arteriograph has been shown in this study and others³⁻⁵ to have an excellent overall accuracy. It is especially accurate in detecting those lesions which are considered to be hemodynamically significant, that is, within categories III and IV. Combining these two groups yields an accuracy rate of 87 percent for the detection of stenosis with a 50 percent or greater diameter reduction. The accuracy rate in detecting a nonhemodynamically significant stenosis is also acceptable—78 percent, when combining categories I and II. Additionally, the sensitivity and specificity rates, each 96 percent, speak well for the test's ability to differentiate between hemodynamically significant and nonhemodynamically significant disease.

This study compares the results obtained with the ultrasonic arteriograph with those obtained by contrast arteriography. Such a process may lend intrinsic bias to the overall accuracy because in this study those patients in whom contrast arteriography was done were symptomatic and might be expected to have a high incidence of advanced atherosclerosis at the carotid bifurcation. Also, because the accuracy of the ultrasonic arteriograph in the detection of a category I or II stenosis is less than that for detecting a category III or IV stenosis, inclusion of a large number of patients with lesser degrees of stenosis could conceivably decrease the overall diagnostic accuracy. This situation might occur in screening a large population of asymptomatic patients. However, the fact remains that in experienced hands, the ultrasonic arteriograph is highly accurate in the detection of a hemodynamically significant stenosis.

Despite this accuracy, two questions remain: (1) What is the role of identification of an asymptomatic carotid stenosis in stroke prevention and (2) should identification of such a stenosis alter the approach to patient management? In an attempt to answer these questions, the avail-

able data concerning the cause of ischemic stroke and the natural history of the asymptomatic bifurcation stenosis are reviewed.

Ischemic Strokes

Transient ischemic attacks and their potential sequela, ischemic stroke, are generally regarded as embolic in nature. The frequency with which fixed neurological deficits are associated with internal carotid artery occlusion appears to be less than previously considered.⁶ Emboli consist of fragments of atherosclerotic plaque or platelet fibrin aggregates that have formed on a previously degenerated plaque (ulcer) and have subsequently been dislodged and carried into the cerebral circulation. As many as 75 percent of such emboli originate in a surgically accessible site in the extracranial cerebral vasculature.² Some investigators have suggested that clusters of embolic episodes may occur from an atherosclerotic lesion, with intervals of several years between individual clusters.⁷ No hard data are available to support this suggestion.

The prevalence of notable atherosclerotic fibrous plaque at the carotid bifurcation in patients older than 65 years of age examined during autopsy studies approaches 100 percent.⁸ In this same age group, complex carotid bifurcation lesions, defined as fibrous plaques with areas of hemorrhage, ulceration, necrosis or thrombosis are found in nearly 40 percent. The reported incidence of complex plaques determined from examination of operative specimens varies widely. Blaisdell and associates⁹ noted ulceration at the time of arteriotomy in 80 percent of the arteries with a 30 percent or greater stenosis. On the other hand, Edwards and associates¹⁰ found ulceration in only 40 percent of their operative specimens. Hertzner and associates¹¹ used scanning electron microscopy of carotid endarterectomy specimens and demonstrated microulceration or thrombus adherent to the vessel wall in eight of ten arteries examined. If atherosclerosis of the carotid bifurcation, either with or without ulceration, was the only determinant of transient ischemic attack and stroke, one would expect the incidence of stroke in the elderly to parallel the incidence of occlusive disease at the bifurcation. However, this incidence is much higher than the current stroke rate estimates of 1 percent per year for this same population.¹² Additional factors, at present poorly defined, must also be operative.

Recent reports have further confused the ulceration

issue. Using life-table methods, Moore and co-workers¹³ reviewed and classified asymptomatic nonstenotic carotid ulcerations into groups containing either small, large or complex ulcerations. Carotid bifurcation endarterectomy was recommended for the combined large and complex ulcer groups based on an observed average annual stroke rate of 12.5 percent. Observation was recommended for the small bifurcation ulcer group based on an average annual stroke rate of 0.4 percent. On the other hand, Kroener and colleagues,¹⁴ using a similar classification and life-table analysis in a similar group of patients, could find no difference in ischemic neurological events between large and small ulcers or between those ulcers associated with a stenotic and those associated with a nonstenotic lesion. Their cumulative seven-year stroke rate was only 1 percent. Unfortunately, of the currently available noninvasive tests, including the ultrasonic arteriograph, none are capable of routinely detecting ulceration.

Independent reports by Thompson¹⁵ and Humphries¹⁶ gave divergent recommendations for the management of asymptomatic bifurcation stenosis based on the observed natural history in their patients. Thompson¹⁵ found a 27 percent incidence of transient ischemic attacks and a 15 percent incidence of stroke without antecedent symptoms in a group of 138 patients with mid-cervical bruits who were not subjected to endarterectomy. Mean follow-up time was 45 months. They concluded that prophylactic endarterectomy was indicated for the asymptomatic stenosis. Unfortunately, arteriograms were obtained in only slightly more than half of the patients, and correlation of the location of the bruit with the type and site of the neurological event was not explicitly stated. In this series, the decision not to operate was made because of overriding associated medical conditions, the nature of the bruit, or the referring physician's or the patient's reluctance to proceed with an operation. Humphries¹⁶ followed 168 patients with asymptomatic stenosis of greater than 50 percent a mean of 32 months. He reported a 15.5 percent incidence of transient ischemic attacks and a 0.5 percent incidence of stroke without antecedent symptoms and concluded that such patients should be followed rather than undergo an endarterectomy. In contrast to Thompson's series, Humphries' series contained a high proportion of patients in whom an endarterectomy had been done previously on the contralateral artery. Such a difference may be important as it has been

suggested that correction of a stenosis on one side may mitigate coexistent contralateral disease.¹⁷

Perioperative stroke remains a devastating complication of many otherwise successful major operative procedures. Some surgeons advise prophylactic endarterectomy for an asymptomatic carotid stenosis in patients about to undergo other major vascular, thoracic or cardiac procedures. The available data do not support this approach. Reports by Carney and co-workers,¹⁸ Evans and Cooperman,¹⁹ and Treiman and colleagues²⁰ have shown virtually identical perioperative stroke rates in patients with asymptomatic stenosis or bruits as compared with those without these findings. If anything, there are slightly more neurological events in those without bruit or documented stenosis. Recognition that an asymptomatic carotid stenosis is but one manifestation of a generalized process—atherosclerosis—should heighten the awareness of the health care team that a patient with such a lesion may be at an increased risk during the perioperative period for cerebrovascular and cardiovascular complications and should permit institution of additional precautionary and prophylactic measures to minimize the possibility of such complications from occurring.

With these opposing opinions on the natural history and the divergent recommendations for treatment of asymptomatic carotid bifurcation disease, the question remains: Where does non-invasive testing in general and ultrasonic arteriography in particular fit into the scheme of patient management? The following recommendations seem prudent.

Patient Management

First, as a diagnostic procedure ultrasonic arteriography is not indicated in patients with classic hemispheric transient ischemic attacks or resolved stroke. Arch and four-vessel arteriography with intracranial views are mandatory to define the anatomy and to plan an operative approach in such patients. Yet this group of patients provides a large pool of arteriogrammed arteries against which the findings of the ultrasonic arteriograph might be compared for determining individual laboratory accuracy rates and for ongoing quality assurance. It is only in this regard that ultrasonic arteriography can be recommended in patients with classic hemispheric ischemic symptoms. As such, it would be inappropriate to charge these patients for such examinations.

Second, patients scheduled for major abdominal, thoracic, vascular or cardiac operations in whom a midcervical bruit is discovered should undergo preoperative ultrasonic arteriography. This should be done to identify the origin of the bruit and heighten the awareness of the health care team to the possibility of increased risk of cardiovascular and cerebrovascular complications. It should not be used to identify patients for prophylactic endarterectomy before the planned procedure, as the efficacy of such a therapeutic approach has not been documented.

Third, evidence that prophylactic endarterectomy in asymptomatic patients alters their subsequent stroke risk is not convincing. Until the natural history of the asymptomatic carotid stenosis is better defined, the use of ultrasonic arteriography to identify asymptomatic patients for prophylactic endarterectomy cannot be justified. However, it might be useful in selecting that group of patients who may have an increased risk of neurological events. Such patients should receive intensive education about the signs and symptoms of transient ischemic attack and stroke and instruction to report promptly to their physicians the development of such findings. Perhaps this approach could decrease the annual stroke rate. However, as there is evidence that the stroke rate has been declining in recent years, this would be hard to document. A consensus on which patients should be included in a high-risk group will be difficult to reach, but it should probably include those with ultrasonic arteriographic evidence of high-grade bifurcation stenosis and those with evidence of unilateral total occlusion of the internal carotid artery.

Finally, in those patients with atypical symptoms that may represent ischemic neurological events, ultrasonic arteriography should be done. Should a significant stenotic lesion be identified, endarterectomy could then be offered, recognizing that only about 15 percent of patients with atypical symptoms will be relieved of their symptoms following the procedure. With additional experience, it may be possible to use the findings of ultrasonic arteriography to help select for endarterectomy that group of patients with atypical symptoms who are most likely to obtain relief of symptoms.

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Mechanism of Mitral Valve

I THINK WE DO an injustice to the mitral valve in saying that if the mitral valve closes one leaflet a little bit above the other and a click or noise is produced, that it's necessarily abnormal. I find it hard to believe that up to 20 percent of the young female population is abnormal. And so I think to a large extent we're calling normal "abnormal." I agree that some people do get in trouble, and they may have increased rhythm disturbances, but generally speaking those are the people who have multiple clicks or midsystolic clicks or late-systolic murmurs. But the person who has just a little asymmetric closure on an echocardiogram and have a very early click—I have the feeling that's within normal limits.

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